TASK 13. REARING FRY SURVEYS, 1990 - 1992

13.1 OBJECTIVE

EBMUD conducted annual seining surveys at several sites in the Lower Mokelumne River. The objectives of these surveys were to determine the relative abundance, distribution and condition of rearing chinook salmon and steelhead rainbow trout over time in the Mokelumne River between Camanche Dam and Lake Lodi (Camanche reach) and between Lake Lodi and Ray Road (Woodbridge reach) during 1990, 1991 and 1992, and to evaluate the effects of in-river conditions on relative abundance, growth and rearing conditions between years.

13.2 METHODS

EBMUD provided BioSystems with the raw data from the 1990-1992 seining surveys in spreadsheet format. Since the data were presented as the number of fish caught per transect length and the transect length differed between sites, the catch per unit effort (CPUE) was standardized to the number of salmon caught per 100 m of shoreline for all sites. It was assumed that the number of seine passes and seining procedures were consistent at each site for each sampling period. Since smolt traps were installed at Woodbridge Dam during April and May of each year, only those sites upstream of the dam were analyzed.

13.2.1 1990 Seining Survey

In 1990, EBMUD conducted seining surveys (16 February-31 May) at six sites between Camanche Dam and Mackville Road (Camanche reach), and at four sites between Woodbridge Dam and Ray Road (Woodbridge reach) (Figure 13-1). Sites were sampled at two-week intervals using a 1.8 m x 9 m, 4 mm delta mesh seine for four to ten passes at each site. At each site, a transect was measured along the shoreline and marked with wooden stakes and then sampled during each survey. Transect length differed between sites due to varying habitat conditions.

Flow through the rearing habitat was determined based on data from the USGS gaging station just below Camanche Dam (USGS gage station #11323500).

During the field surveys, collected fish were anesthetized with tricaine methanesulphonate (MS-222) buffered with sodium bicarbonate. Each fish collected was identified to species. Fork lengths were measured to the nearest millimeter for each salmon processed. When over 30 salmon were caught at a site, a subsample of at least 30 fish were measured (length and weight). The weight of individual salmon was determined by volumetric displacement in a graduated cylinder. Fulton condition factor (K) was calculated for all processed fish using fork length and weight in grams.

After processing, all fish were placed into a bucket filled with fresh river water to recover from the anesthetic before being returned to the river.

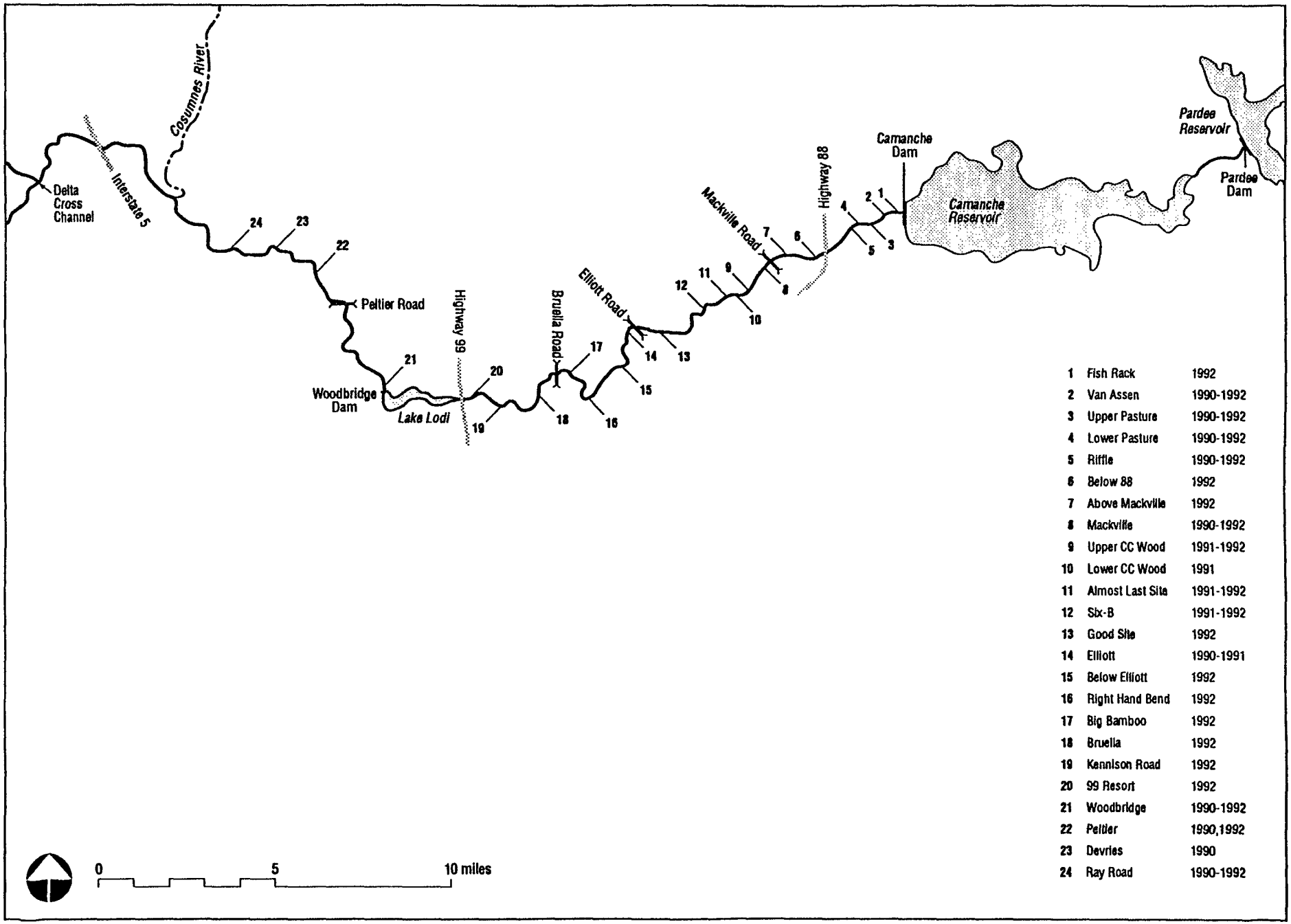

Figure 13-1. Locations of Mokelumne River seining survey sites, 1990-1992.

13.2.2 1991 Seining Survey

During 1991, bi-monthly surveys were conducted from 21 February through 29 May using similar methods to those used in the 1990 study. However, sampling in 1991 focused primarily on the river section in the Camanche reach. Ten sites were sampled: nine sites between Camanche Dam and Woodbridge Dam and one site immediately downstream of Woodbridge Dam (Woodbridge site) (Figure 13-1).

13.2.3 1992 Seining Survey

In 1992, seining surveys were conducted from 31 January through 28 May. Thirteen sites were surveyed bi-monthly in the Camanche reach, including five sites between Camanche Dam and Mackville Road, five sites between Mackville Road and Elliott Road, and three sites between Elliott Road and Bruella Road (Figure 13-1). There were five additional sites sampled irregularly during the 1992 surveys. These included the Bruella and Kennison sites which were seined once (29 January and 4 March, respectively), the Highway 99 and Ray Road sites which were seined three times in May, and the Peltier site where seining was discontinued because of debris and low flows.

Maps of the 1990 and 1991 seining sites enabled these earlier surveys to be duplicated in 1992. As a result of site adjustments in all years, only four sites in the Camanche reach have been seined in each of the three years (Figure 13-1).

Sampling methods used in 1992 were similar to those used in the earlier surveys with the exception that all salmon in 1992 were weighed individually to the nearest 0.1 g using a portable electronic balance (Ohaus Model CT600) instead of volumetric displacement.

Analysis of variance (ANOVA) was conducted to examine whether the differences in CPUE were related to differences in sampling periods (week effect), sampling years (year effect) or in different bi-monthly periods of a year (interactive effect). If the interactive effect was not significant or was significant but had much lower F-values than those of the main effects (week and year), multiple comparison tests were conducted to examine the difference among bi-monthly periods and among years. These statistical analyses were repeated for length and for condition factor.

13.3 RESULTS

13.3.1 Catch Per Unit Effort (CPUE)

The calculated CPUE for all six sites sampled in 1990 are outlined in Table 13.1. Salmon fry were most abundant at the Lower Pasture and Mackville sites. The CPUE for these sites ranged from 0.0 to 215.8 fish/100 m at the Lower Pasture site, and from 26.6 to 217.3 fish /100 m at the Mackville site. Salmon were less abundant at the Elliott Road site (CPUE range= 0.0-9.4 fish/100 m). Fry were recorded throughout the sample period (16 February to 31 May) with peak abundance at most sites occurring from March to late April (Table 13.1).

Table 13.1. Summary of each catch per unit effort (CPUE) for chinook salmon fry collected during the EBMUD seine surveys, 1990 - 1992 (only sites located above Woodbridge Dam are given).

		JANUARY	FEBRUARY		MARCH		APRIL		MAY		
SITE	LENGTH (m)	WEEK 5	WEEK 1	WEEK 3	WEEK 1	WEEK 3	WEEK 1	WEEK 3	WEEK 1	WEEK 3	WEEK 4
1990											
Van Assen	82.6			2.4	6.1	3.6	65.4	1.2	1.2	0.0	2.4
Upper Pasture	77.7					11.6	24.4	24.4	0.0	0.0	99.1
Lower Pasture	57.0					12.3	215.8	86.0	166.7	0.0	15.8
Resolution Riffle	77.1					92.1	98.6	42.8	16.9	35.0	11.7
Mackville	71.3			22.4	217.3	213.1	67.3	214.5	26.6	46.3	29.4
Elliott	128.0				2.3		9.4	3.9	0.8	0.0	0.0
1991											
Van Assen	82.6			0.0	15.7	7.3	15.7	0.0	6.1	1.2	0.0
Upper Pasture	77.7			38.6	21.9	100.4	105.5	68.2	96.5	9.0	19.3
Lower Pasture	57.0			36.8	1.8	43.9	10.5	0.0	10.5	0.0	3.5
Resolution Riffle	77.1			5.2	22.0	37.6	15.6	3.9	23.3	2.6	0.0
Mackville	71.3			123.4	70.1	33.7	28.0	2.8	0.0	15.4	2.8
Lower CC Woods	68.6				14.6		24.8		30.6		2.9
Almost Last Site	48.5				8.3		22.7		28.9		0.0
Six B	55.5				356.9		12.6		14.4		3.6
Elliott	128.0			0.0		9.4		0.0		0.0	
1992											
Below Cat.	82.9			126.7	147.2	224.4	345.0	367.9	45.8	22.9	22.9
Van Assen	48.2	0.0	12.5	56.1	184.8	415.3	305.3	10.4	18.7	4.2	2.1
Upper Pasture	64.9		0.0	10.8	69.3	41.6	40.0	80.1	86.3	63.2	3.1
Resolution Riffle	77.1		0.0	2.6	0.0	3.9	16.9	16.9	3.9	16.9	7.8
Above Mackville	77.4			94.3	47.8	94.3	308.7	236.4	139.5	174.4	109.8
Mackville	71.3	0.0	0.0	267.8	106.6	367.4	283.2	92.5	88.3	14.0	8.4
Upper CC Woods	42.7		2.3	154.7	2.3	2.3	0.0	35.2	35.2	2.3	2.3
Almost Last Site	46.9		0.0	66.0	413.3	159.8	481.5	115.0	104.4	89.5	132.1
Six B	55.5		1.8	57.7	128.0	32.4	77.5	27.0	1.8	7.2	7.2
Good Site	51.8			21.2	30.9	69.5	25.1	0.0	0.0	3.9	17.4
Below Elliott	59.1			8.5	49.0	49.0	109.9	8.5	0.0	0.0	0.0
R.H. Bend	57.0			15.8	152.6	103.5	0.0	56.1	5.3	8.8	0.0
Big Bamboo	51.5			7.8	40.8	23.3	7.8	5.8	1.9	1.9	0.0
99 Resort	81.4								0.0	2.5	3.7

The sampling sites in 1991 included three additional sites between Mackville and Elliott Roads. Salmon fry were recorded from all sites in the Camanche reach (Table 13.1). Fry were most abundant at one of the additional sites (Six B site, CPUE range= 3.6-356.9 fish/ 100 m), and at Mackville (CPUE range= 0.0 to 123.4 fish/100 m) (Table 13.1). The highest CPUE's for most sites were between late February and the first week in April.

Surveys in 1992 included 11 additional sites, eight of which were downstream of Mackville Road (Figure 13-1). The highest CPUE values were recorded at the site termed "Almost Last Site" between Mackville and Elliott Roads (CPUE range= 0.0-481.5 fish/ 100 m) (Table 13.1). Salmon fry were also abundant at Mackville, Above Mackville, and Van Assen Park sites (Table 13.1). All of these sites are adjacent to or immediately downstream of areas where significant spawning activity was recorded during the fall run (Task 10). The CPUE for the Fish Rack site near the MRFH also indicated that salmon fry were numerous (Table 13.1). However, emergence studies (Task 12) indicated that few salmon fry were produced at this location. It is possible that salmon fry may have dispersed upstream from more productive areas or that fry escaped from the hatchery resulting in a high CPUE for this site. Salmon fry were abundant at most sites from late February to late April.

Based on CPUE analysis, salmon fry during 1990, 1991, and 1992 appeared to be concentrated at sites located from Camanche Dam to downstream of Mackville Road (site Six B) (Table 13.1). Based on these results, the vast majority of salmon rearing occurs upstream of Elliott Road, particularly in the vicinity of Mackville Road.

Four sites (Van Assen, Upper Pasture, Resolution Riffle, and Mackville) were sampled during all three years and were used to test differences in CPUE between sampling periods and sampling years (Table 13.2). The results of ANOVA indicated the effect of interaction between week and year was not significant ($p > 0.05$); therefore, the CPUE's were compared among the three years using Duncan's Multiple Range Test. The CPUE in 1992 was significantly higher ($p < 0.05$) compared to the CPUE in 1991. However, the CPUE in 1990 was not significantly different ($p > 0.05$) from that in 1991 or 1992. This difference in the numbers of salmon between 1991 and 1992 was also observed at Woodbridge Dam during subsequent emigration studies (Task 14), with relatively greater numbers of smolts being taken during 1992 compared to 1991 (Task 14).

In 1990, mean CPUE peaked in early March (111.7 fish/100 m) and steadily declined until the first week in May (Table 13.2). In 1991, the mean CPUE was fairly consistent from late February through early April, but relatively low catches were recorded throughout the sampling period (Table 13.2). In 1992, mean CPUE peaked during the third week in March and the first week in April, 207.1 and 161.4 fry/100 m, respectively.

Generally, the low CPUE obtained after early April in all three years coincided with increased flow releases below Camanche Dam (Figure 13-2). In 1990, mean daily flows increased during the surveys from approximately 100 cfs in February to over 300 in May (range= 92-307 cfs) (Figure 13-2a). In 1991, mean daily flows ranged from 94 cfs in

Table 13.2. Summary of catch per unit effort (CPUE) for all sites seined during the three EBMUD surveys, 1990 - 1992. Sites include Van Assen, Upper Pasture, Resolution Riffle, and Mackville.

		JANUARY	FEBRUARY		MARCH		APRIL		MAY		
SITE	LENGTH (m)	WEEK 5	WEEK 1	WEEK 3	WEEK 1	WEEK 3	WEEK 1	WEEK 3	WEEK 1	WEEK 3	WEEK 4
1990											
Van Assen	82.6			2.4	6.1	3.6	65.4	1.2	1.2	0.0	2.4
Upper Pasture	77.7					11.6	24.4	24.4	0.0	0.0	99.1
Resolution Riffle	77.1					92.1	98.6	42.8	16.9	35.0	11.7
Mackville	71.3			22.4	217.3	213.1	67.3	214.5	26.6	46.3	29.4
Mean				12.4	111.7	80.1	63.9	70.7	11.2	20.3	35.7
SD				14.1	149.3	97.3	30.4	97.4	12.9	23.9	43.7
1991											
Van Assen	82.6			0.0	15.7	7.3	15.7	0.0	6.1	1.2	0.0
Upper Pasture	77.7			38.6	21.9	100.4	105.5	68.2	96.5	9.0	19.3
Resolution Riffle	77.1			5.2	22.0	37.6	15.6	3.9	23.3	2.6	0.0
Mackville	71.3			123.4	70.1	33.7	28.0	2.8	0.0	15.4	2.8
Mean				41.8	32.4	44.7	41.2	18.7	31.5	7.1	5.5
SD				57.0	25.3	39.5	43.3	33.0	44.5	6.5	9.3
1992											
Van Assen	48.2	0.0	12.5	56.1	184.8	415.3	305.3	10.4	18.7	4.2	2.1
Upper Pasture	64.9		0.0	10.8	69.3	41.6	40.0	80.1	86.3	63.2	3.1
Resolution Riffle	77.1		0.0	2.6	0.0	3.9	16.9	16.9	3.9	16.9	7.8
Mackville	71.3	0.0	0.0	267.8	106.6	367.4	283.2	92.5	88.3	14.0	8.4
Mean			3.1	84.3	90.2	207.0	161.3	50.0	49.3	24.5	5.3
SD			6.2	124.6	77.0	214.3	154.0	42.4	44.3	26.3	3.2

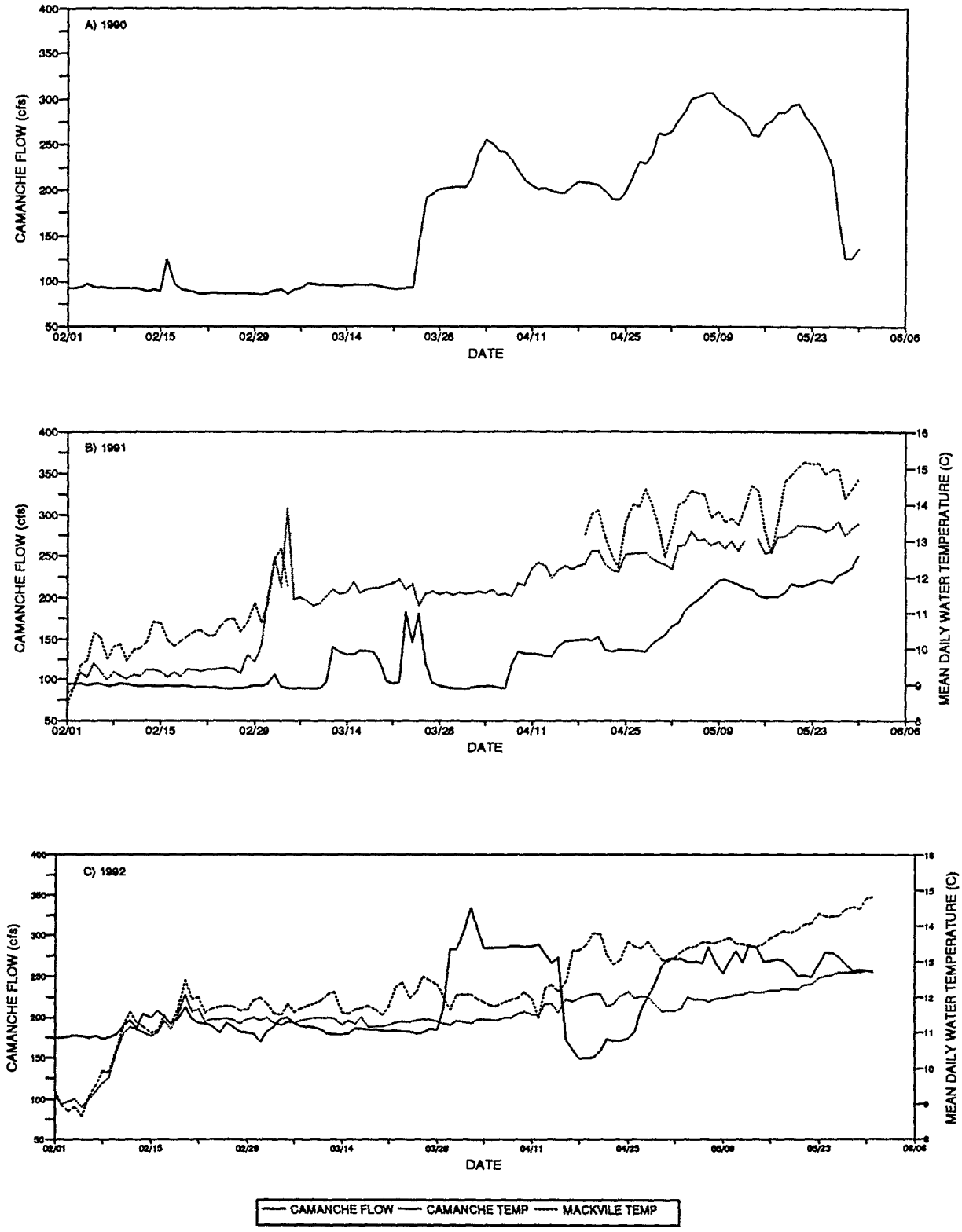

Figure 13-2. Mean daily flow releases from Camanche Dam (USGS Gage Station #11323500) and mean daily water temperature recorded at Camanche Dam and Mackville Road (EBMUD datapods) during EBMUD seining surveys during A) 1990, B) 1991, and C) 1992.

February to 220 cfs in late May (Figure 13-2b). The flows during the 1992 surveys were generally higher than during the surveys of the previous two years (range= 174-280 cfs) (Figure 13-2c).

Temperatures during the three-year study were suitable for rearing salmon fry. In general, mean daily water temperature in the river remained under 14° C (Figure 13-2). No data on mean daily temperatures were collected during 1990; however, daily water temperatures collected at the seining sites ranged from 10° C to 15° C (Hagar 1991). In 1991, mean daily water temperatures measured at Camanche Dam during sampling ranged from 8.7° C to 13.9° C (Figure 13-2b). During this time, only partial data were available from the downstream site at Mackville Road where temperatures ranged from 8.5° C to 15.2° C. In 1992, mean daily water temperatures ranged from 8.9° C to 12.8° C at Camanche Dam, and from 8.6° C to 14.8° C at Mackville Road (Figure 13-2c).

13.3.2 Fry Length and Condition Factor

Mean fork length of salmon fry collected in 1990, 1991, and 1992 in Camanche reach are presented in Figure 13-3 and Table 13.3. In 1990, mean fry length increased from 41.3 mm (SD= 4.8) in late March to 79.0 mm in late May (SD= 10.6). In 1991, mean length increased from 41.5 mm (SD= 4.6) in late February to a mean of 85.9 mm (SD= 10.2) observed in late May (Figure 13-3). In 1992, mean length ranged from 38.4 mm (SD= 8.1) in February to 86.1 (SD= 8.5) in late May. Mean fork lengths were consistently lower in seining surveys during April and May than those recorded at Woodbridge Dam during concurrent emigration studies.

High numbers of newly emergent fry (30-45 mm) were caught in each sample collected from late February to early April. Larger fry ($\geq$ 70 mm) were first collected in early April samples in 1990 and 1992, but were collected in late March samples during 1991 seining. The results of ANOVA indicated that there was a significant difference in length based on weeks (F-value= 1468.0, $p < 0.05$) and based on years (F-value= 244.4, $p < 0.05$). This test also indicated there was a significant interactive effect between years and weeks, however the significance was much lower (F-value= 33.6, $p < 0.05$). Student-Newman-Keuls analysis indicated that there was a significant difference in the lengths in all three years with the mean length of the salmon in 1990 being the largest and the mean length in 1992 being the smallest.

Mean Fulton condition factors (based on fork length in mm) for salmon fry collected during the 1990, 1991, and 1992 seining surveys are presented in Table 13.3. In 1990, mean condition factor varied from a low of 1.00 in early May, to a high of 1.17 in late March (Table 13.3). In 1991, low condition factors were recorded during late February (mean= 0.96), and the highest mean condition factor was observed in late May (1.27). In 1992, mean condition factors ranged from 0.89 in late March to 1.23 in late May (Table 13.3). The results of ANOVA indicate that there was a significant difference in condition factor among

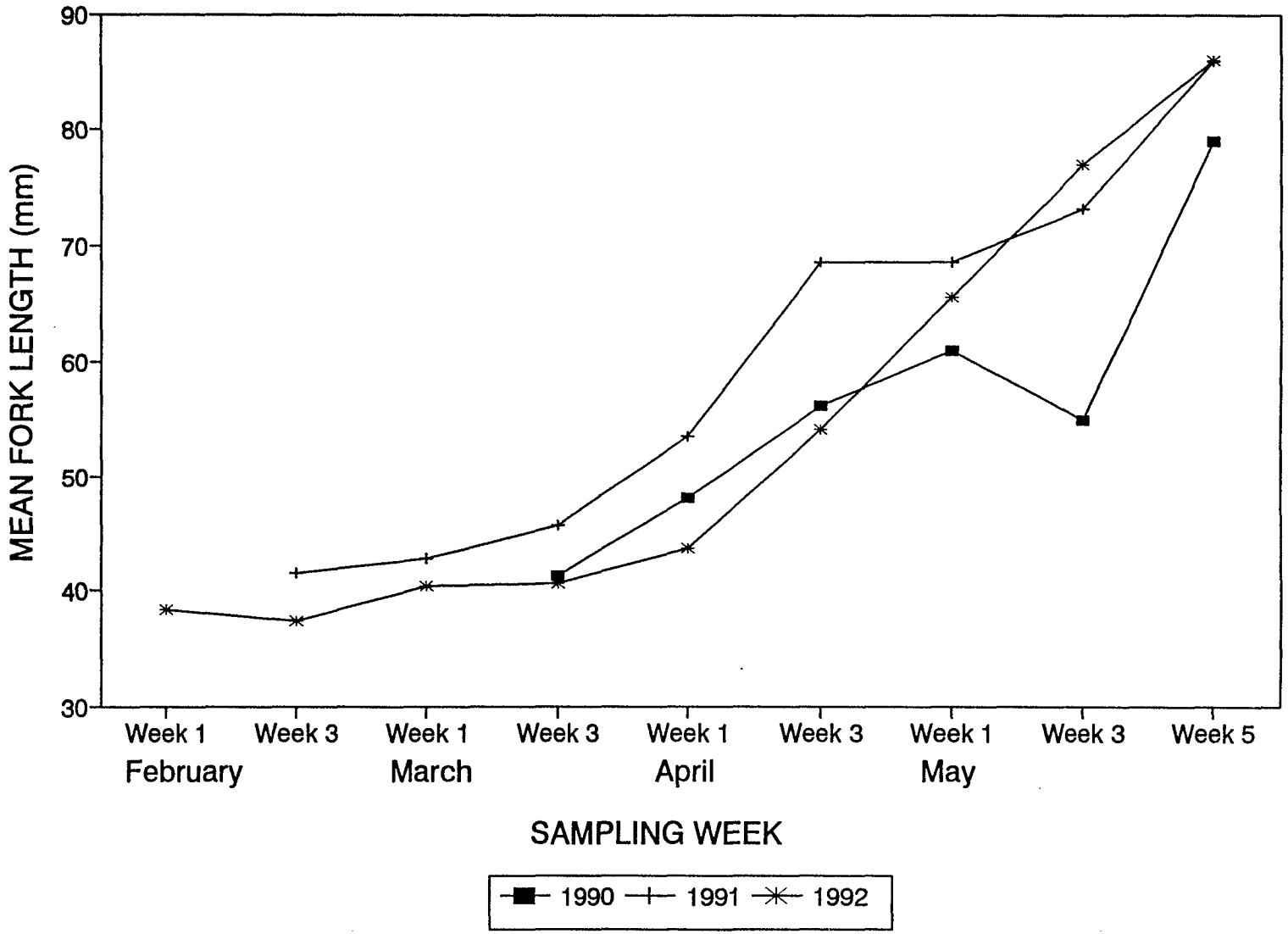

Figure 13-3. Mean fork length (mm) of chinook salmon during the bi-monthly EBMUD seining surveys, 1990-1992.

Table 13.3. Mean Fulton condition factors and mean fork lengths for chinook salmon fry collected during bi-monthly EBMUD seining surveys on the Mokelumne River, 1990-1992.

	CONDITION FACTOR			FORK LENGTH		
	MEAN	STDS.	N	MEAN	STDS.	N
1990						
March						
Week 1						
Week 3	1.17	0.42	35	41.3	4.8	35
April						
Week 1	1.15	0.52	94	48.0	9.6	94
Week 3	1.11	0.23	81	56.2	7.7	81
May						
Week 1	1.00	0.18	64	61.0	11.6	64
Week 3	1.02	0.10	60	54.9	11.1	60
Week 5	1.14	0.09	70	79.0	10.6	70
1991						
February						
Week 3	0.96	0.14	141	41.5	4.59	141
March						
Week 1	0.97	0.14	122	42.8	8.41	122
Week 3	0.94	0.18	153	45.7	8.54	153
April						
Week 1	1.02	0.16	121	53.5	14.0	121
Week 3	1.04	0.20	37	68.7	17.4	37
May						
Week 1	1.22	0.25	99	68.6	16.5	99
Week 3	1.24	0.24	27	73.1	15.8	27
Week 5	1.27	0.11	26	85.9	10.2	26
1992						
February						
Week 1	0.95	0.25	8	38.4	8.1	8
Week 3	0.90	0.17	232	37.4	4.0	563
March						
Week 1	0.95	0.18	788	40.4	4.8	788
Week 3	0.89	0.16	981	40.6	7.2	981
April						
Week 1	0.97	0.16	1,264	43.7	9.1	1,264
Week 3	1.03	0.16	748	54.1	11.4	748
May						
Week 1	1.14	0.12	347	65.6	12.8	347
Week 3	1.16	0.11	272	76.9	10.8	273
Week 5	1.23	0.10	194	86.1	8.5	194

weeks (F-value= 54.8, $p < 0.05$) and among years (F-value= 19.6, $p < 0.05$). Because the significance of the interactive effect between week and years (F-value= 22.8, $p < 0.05$) was comparable to the main effects of week and year, the significance of the individual effects of weeks or of years became inconclusive and further analysis was not conducted.

13.3.3 Steelhead Rainbow Trout and Other Species

A total of 5 young-of-year steelhead rainbow trout were captured during seining in 1990. Steelhead rainbow trout fry were more abundant in 1991 (79 fish) and 1992 (81 fish) (Table 13.4). The mean condition factor for steelhead rainbow trout was 1.07 in 1991 and 0.98 in 1992. The majority of trout fry were collected during May in 1991 and during April in 1992.

Other fish species collected during all three years are outlined in Table 13.5. Data presented for 1990 is only representative of sites downstream of Woodbridge Dam. During the three-year study, sculpins, Sacramento suckers, mosquitofish, and bluegills were the most abundant fishes. Other species of interest included Sacramento squawfish and largemouth bass (Table 13.5).

Table 13.4. Number of steelhead rainbow trout fry collected during 1990, 1991, and 1992 EBMUD seining surveys. Mean Fulton condition factors and mean fork lengths for trout fry are also shown.

	CONDITION FACTOR			FORK LENGTH		
	N	MEAN	STDS.	N	MEAN	STDS.
1990						
Number Caught	5					
1991						
March						
Week 3	3	0.61	0.21	3	24.0	0.00
April						
Week 1	5	0.74	0.35	12	36.1	3.15
Week 3	1	0.64		1	43.0	
May						
Week 1	38	1.09	0.28	38	33.4	7.02
Week 3	5	1.07	0.14	5	33.2	5.63
Week 5	17	1.24	0.16	18	69.4	41.03
Overall	69	1.07	0.29	77	42.0	25.34
Number Caught	79					
1992						
March						
Week 3	5	0.74	0.19	5	27.6	1.14
April						
Week 1	8	0.91	0.29	8	30.1	4.09
Week 3	29	0.93	0.21	29	28.4	3.34
May						
Week 1	7	1.01	0.16	7	34.9	7.52
Week 3	16	1.08	0.30	16	38.1	6.92
Week 5	12	1.11	0.10	12	56.5	15.31
Overall	77	0.98	0.24	77	35.5	12.28
Number Caught	88					

Table 13.5. Other fish species collected on the Mokelumne River during EBMUD seining surveys, 1990-1992.

COMMON NAME	SCIENTIFIC NAME	1990+	1991	1992
Bass spp.	*Centrarchidae* spp.	17	4	5 *
Largemouth bass	*Micropterus salmoides*	0	0	13
Brown bullhead	*Ameiurus nebulosus*	0	1	0
Black crappie	*Pomoxis nigromaculatus*	0	1	4
Bluegill	*Lepomis macrochirus*	117	40	58
Channel catfish	*Ictalurus punctatus*	1	0	0
Catfish spp.	*Ictalurus* spp.	1	0	0
Mosquitofish	*Gambusia affinis*	755	407	311 *
Golden shriner	*Notemigonus crysoleuces*	0	6	70
Green sunfish	*Lepomis cyanellus*	2	12	4
Redear sunfish	*L. microlophus*	21	3	2
Pacific lamprey	*Lampetra tridentata*	0	1	0
Hitch	*Lavina exilicauda*	0	0	41
Sculpins	*Cottus* spp.	14	1,233	578 *
Sacramento sucker	*Catostomus occidentalis*	101	1,629	123 *
Sacramento squawfish	*Ptychocheilus grandis*	0	113	44
Unidentified cyprinids	*Cyprinidae*	3	1,257	3

+ Only included data from sites downstream of Woodbridge Dam
* Indicates incomplete count